

AFE 76s2 Report

Derivation of Radar Altimeter Interference Tolerance Masks

**Volume I: Introduction,
Test Procedures, and
Fundamental Test Results**

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3.4 Usage Category 3 (200' AGL)

3.4.1 Summary

Table 3-41: UC3 200' AGL Test Conditions

Source	Rationale	Signal Type	Characteristics	Setting
VSG	5G Fundamental OOBI	OFDM	100 MHz TM1.1 centered at 3750 MHz, 3850 MHz, 3930 MHz	Power Sweep
VCOs 1-2	Own-ship multiplex installation	FMCW	CF: 4300 MHz BW/Sweep Rate per AUT	ON*
VCOs 3-16	WCLS – other aircraft	FMCW	Does not apply to UC3	OFF

* – For altimeters capable of multiplex operation. Altimeters I and V had VCO's 1-2 turned off.

Table 3-42: UC3 200' AGL OOB Fundamental Emissions Break Points

Altimeter	200 ft, Own-Ship VCOs											
	3750 MHz				3850 MHz				3930 MHz			
	ME	1%	99%	NCD	ME	1%	99%	NCD	ME	1%	99%	NCD
A[†]	NB*	NB*	NB*	NB*	NB*	NB*	NB*	NB*	NB*	NB*	NB*	NB*
I	-30 dBm*	-31 dBm	-31 dBm	-29 dBm	-28 dBm	-32 dBm	-30 dBm*	-29 dBm	-28 dBm*	-35 dBm	-26 dBm	-25 dBm
S	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB
V	-46 dBm	NB	-42 dBm*	-41 dBm	-38 dBm	NB	-34 dBm	-34 dBm	-37 dBm*	NB	-36 dBm	-36 dBm
ITM	-48 dBm				-44 dBm				-43 dBm			
PSD	-68 dBm/MHz				-64 dBm/MHz				-63 dBm/MHz			

* – Indicates engineering judgement was applied to determine break point

† – See explanation in Section 3.4.2.

3.4.2 Altimeter A

Altimeter A did not have test data collected for the UC3 200 ft, Own-Ship VCOs scenario. Engineering judgement was applied to determine that Altimeter A would have no break points observed if data had been collected. This was justified because the UC2 200 ft, VCOs On (WCLS) scenario incorporates both own-ship in-band interference and in-band interference from other aircraft on the ground. In contrast, the UC3 200 ft, Own-Ship VCOs scenario only had own-ship in-band interference but no in-band interference from other aircraft on the ground. Therefore, the UC3 200 ft scenario interference tolerance levels were expected to be higher than the interference tolerance levels for the UC2 200 ft scenario. Table 3-42 shows that this is the case for Altimeters I and V. Consequently, since no break points were observed for Altimeter A in the UC2 200 ft scenario results, the expected UC3 200 ft scenario results for Altimeter A also would be no observed break points.

This was further justified because Altimeter S had test data collected for the UC3 200 ft scenario and, similar to Altimeter A, Altimeter S had no break points observed in its UC2 200 ft WCLS results and also had no break points observed in its results for the less stringent UC3 200 ft scenario.

3.4.3 Altimeter I

For Altimeter I at 200 feet AGL, valid measured heights appear to be rounded to the nearest 5 feet. Subject matter experts agreed it was necessary to apply engineering judgement to take this height quantization into account when determining the break points.

Table 3-43: UC3 RA-I 200' AGL OOB Fundamental Emissions Break Point Summary

Center Frequency	Plot	Comments
3750 MHz	Time History Figure 3-213	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-214 Figure 3-215	<p>1st percentile measured height is less than the -2% criterion threshold at -31 dBm.</p> <p>99th percentile measured height is greater than the +2% criterion threshold at -31 dBm.</p> <p>Mean error first exceeds the $\pm 0.5\%$ criterion threshold at -30 dBm.</p> <p>The first NCD occurs at -29 dBm.</p> <p>As described above, engineering judgment was applied due to the height quantization for this altimeter at this altitude. Thus, the break point is set by the mean error criterion at -30 dBm.</p>
3850 MHz	Time History Figure 3-216	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-217 Figure 3-218	<p>1st percentile measured height is less than the -2% criterion threshold at -32 dBm.</p> <p>99th percentile measured height is greater than the +2% criterion threshold at -30 dBm.</p> <p>The first NCD occurs at -29 dBm.</p> <p>Mean error first exceeds the $\pm 0.5\%$ criterion threshold at -28 dBm.</p> <p>As described above, engineering judgment was applied due to the height quantization for this altimeter at this altitude. In this case, subject matter experts determined that the break point is set by the 99th percentile criterion at -30 dBm.</p>

Center Frequency	Plot	Comments
3930 MHz	Time History Figure 3-219	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-220 Figure 3-221	<p>1st percentile measured height is less than the -2% criterion threshold at -35 dBm.</p> <p>Mean error first exceeds the $\pm 0.5\%$ criterion threshold at -28 dBm.</p> <p>99th percentile measured height is greater than the +2% criterion threshold at -26 dBm.</p> <p>The first NCD occurs at -25 dBm.</p> <p>As described above, engineering judgment was applied to due to the height quantization for this altimeter at this altitude. Thus, the break point is set by the mean error criterion at -28 dBm.</p>

Center Frequency = 3750 MHz

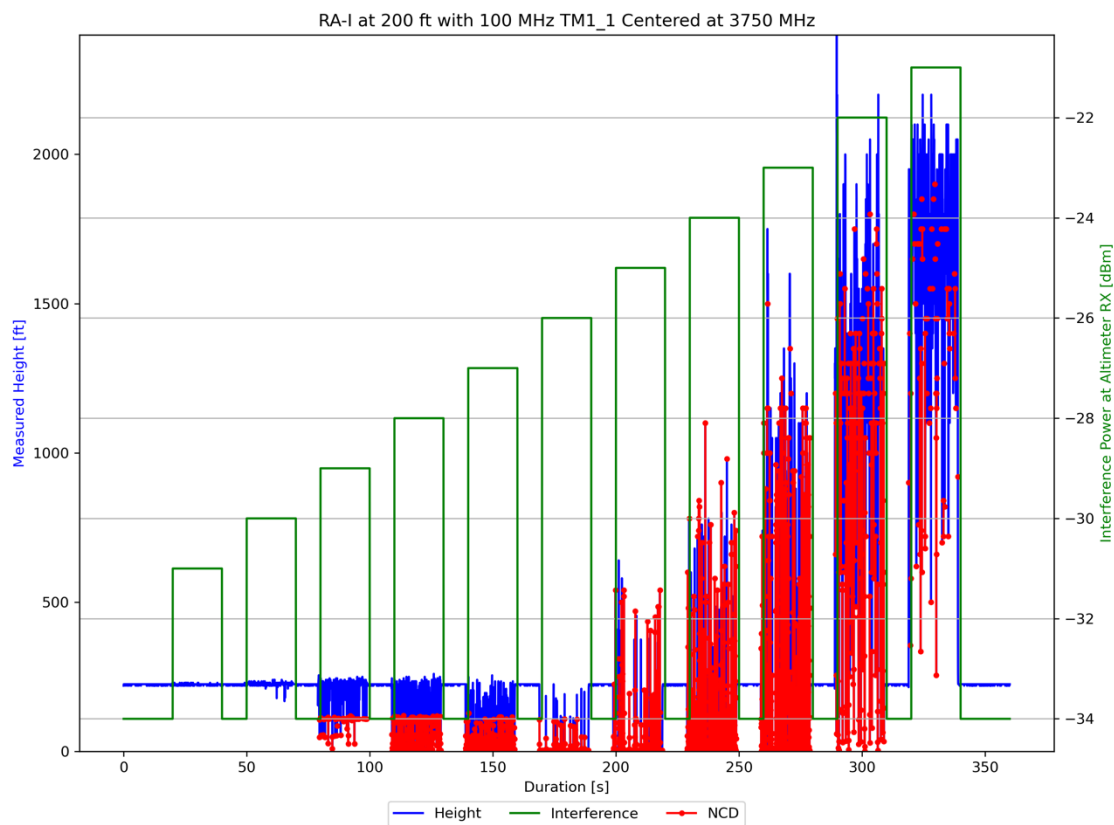


Figure 3-213: UC3 RA-I 200' AGL Time History with TM1.1 at 3750 MHz

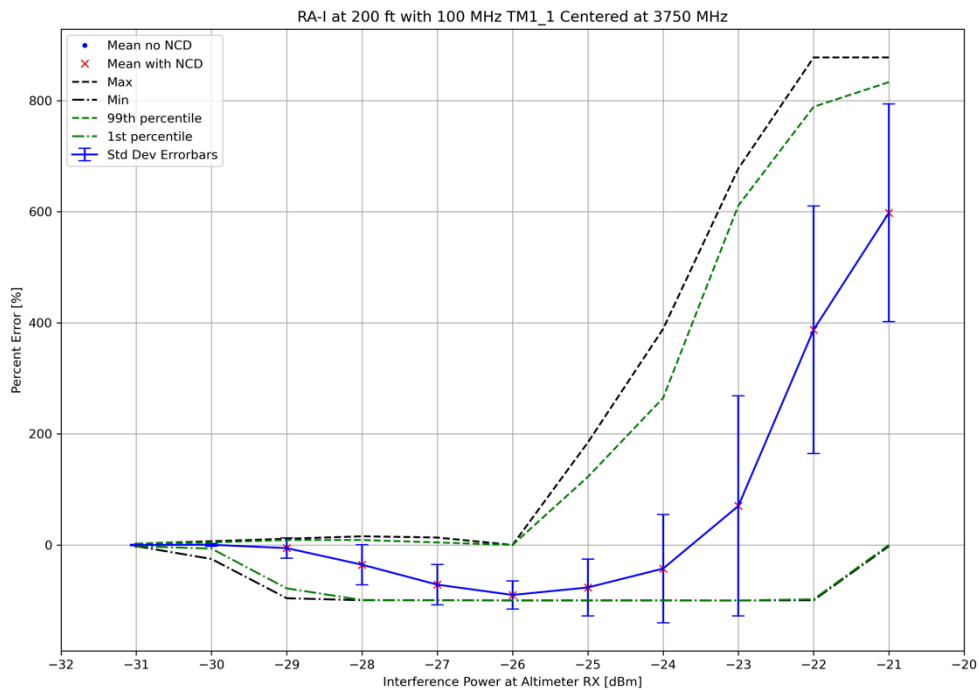


Figure 3-214: UC3 RA-I 200' AGL Statistics with TM1.1 at 3750 MHz – Zoomed Out

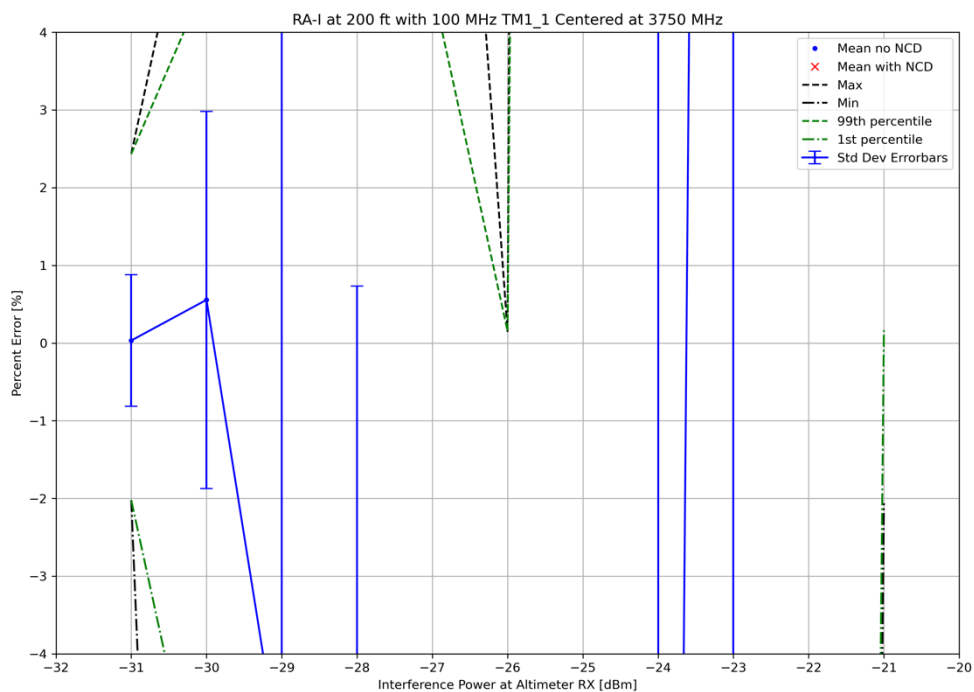


Figure 3-215: UC3 RA-I 200' AGL Statistics with TM1.1 at 3750 MHz – Zoomed In

Center Frequency = 3850 MHz

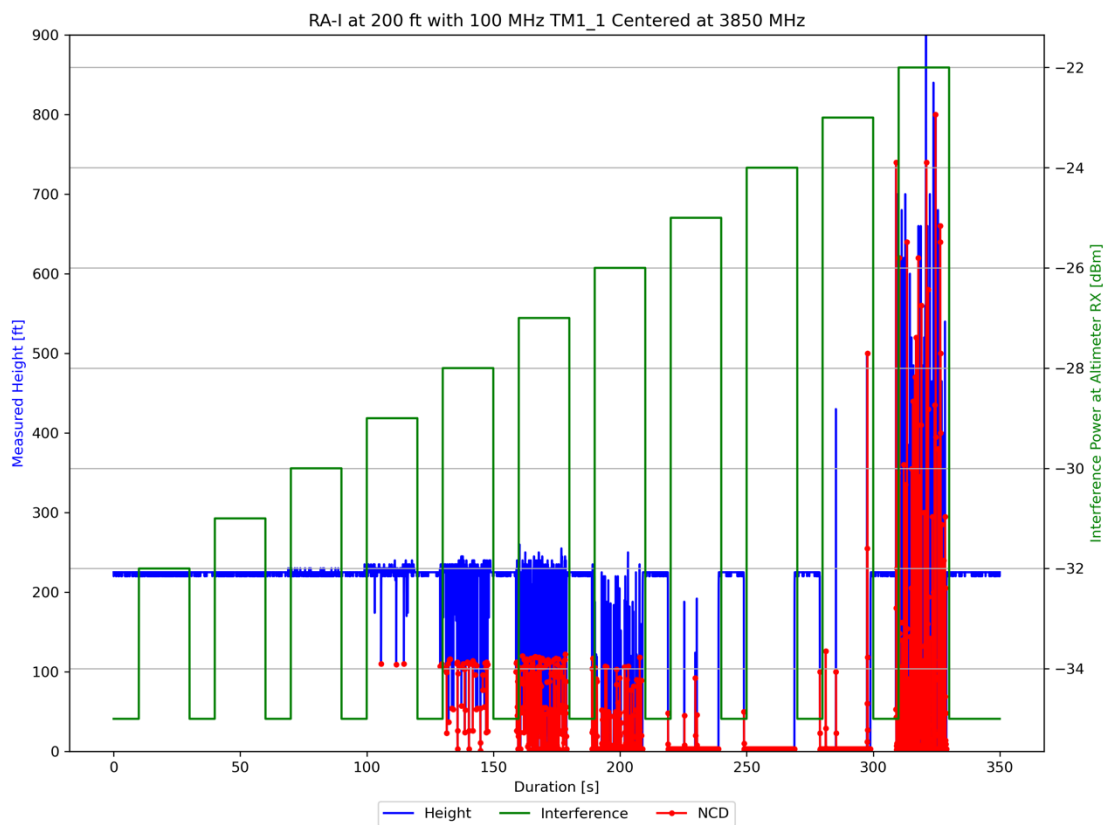


Figure 3-216: UC3 RA-I 200' AGL Time History with TM1.1 at 3850 MHz

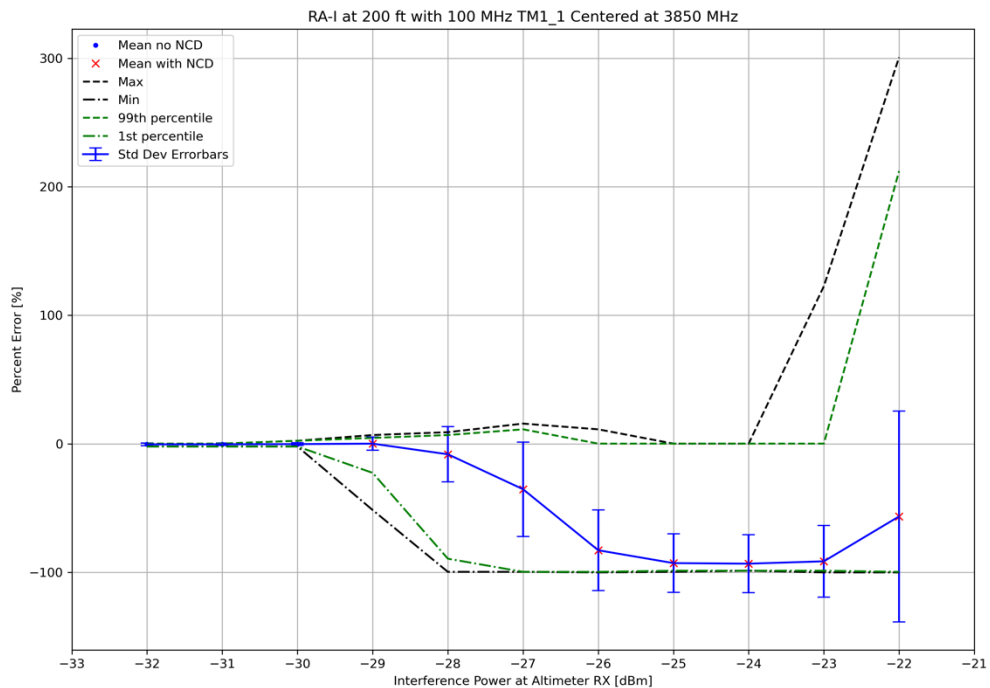


Figure 3-217: UC3 RA-I 200' AGL Statistics with TM1.1 at 3850 MHz – Zoomed Out

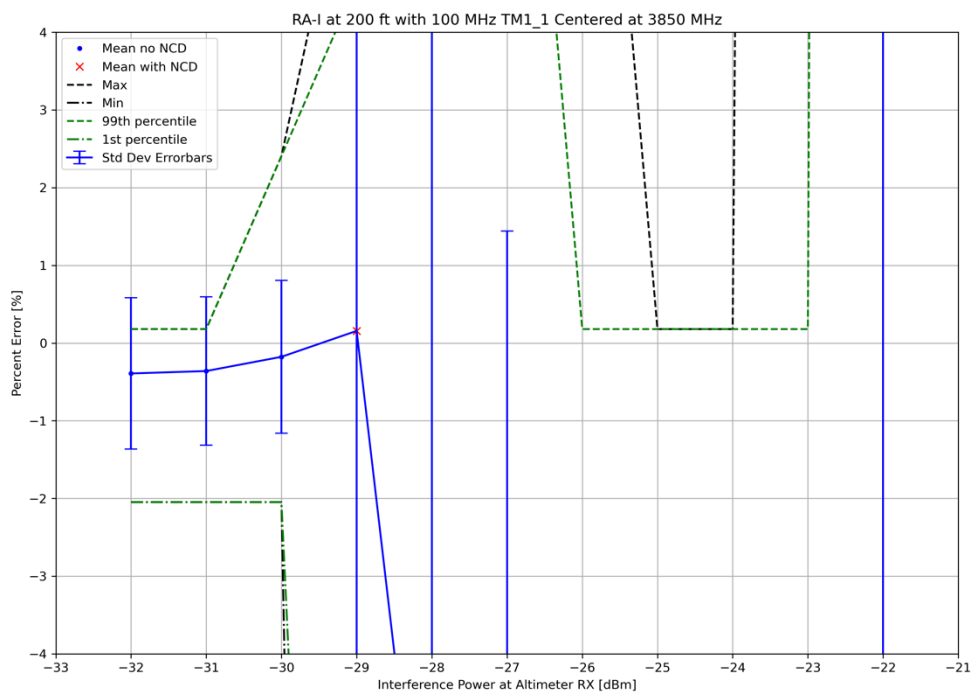


Figure 3-218: UC3 RA-I 200' AGL Statistics with TM1.1 at 3850 MHz – Zoomed In

Center Frequency = 3930 MHz

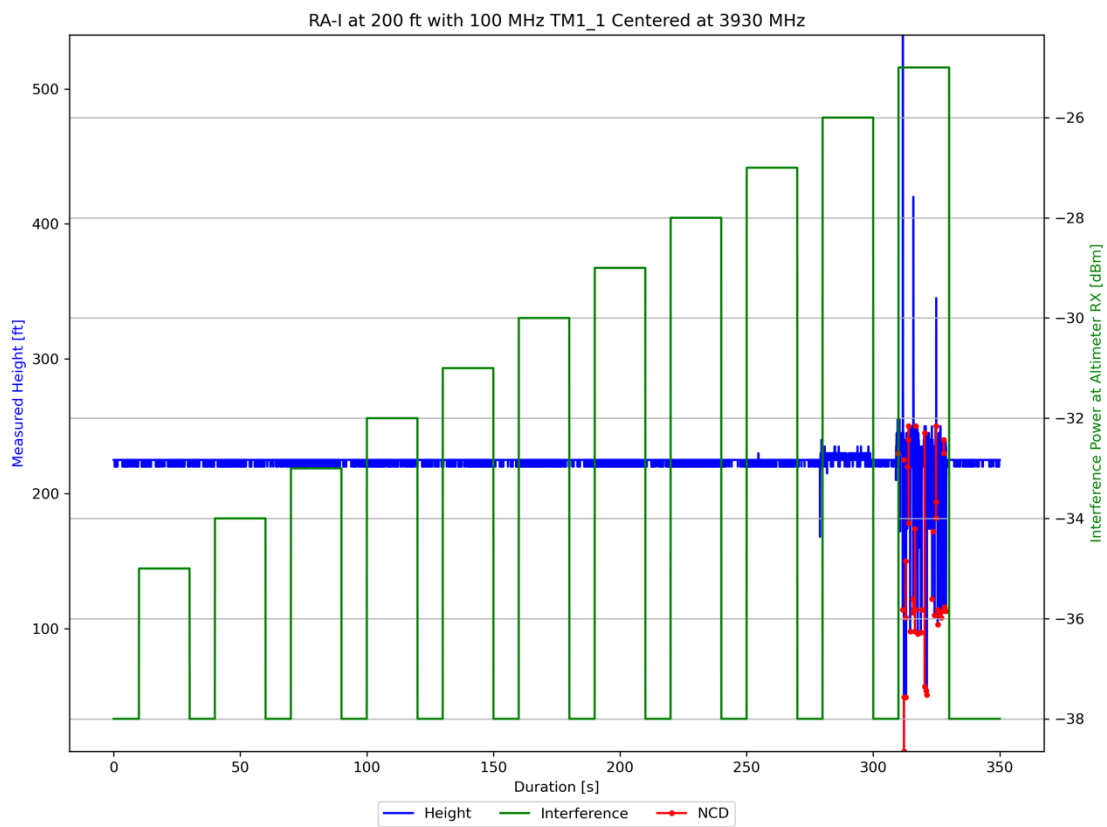


Figure 3-219: UC3 RA-I 200' AGL Time History with TM1.1 at 3930 MHz

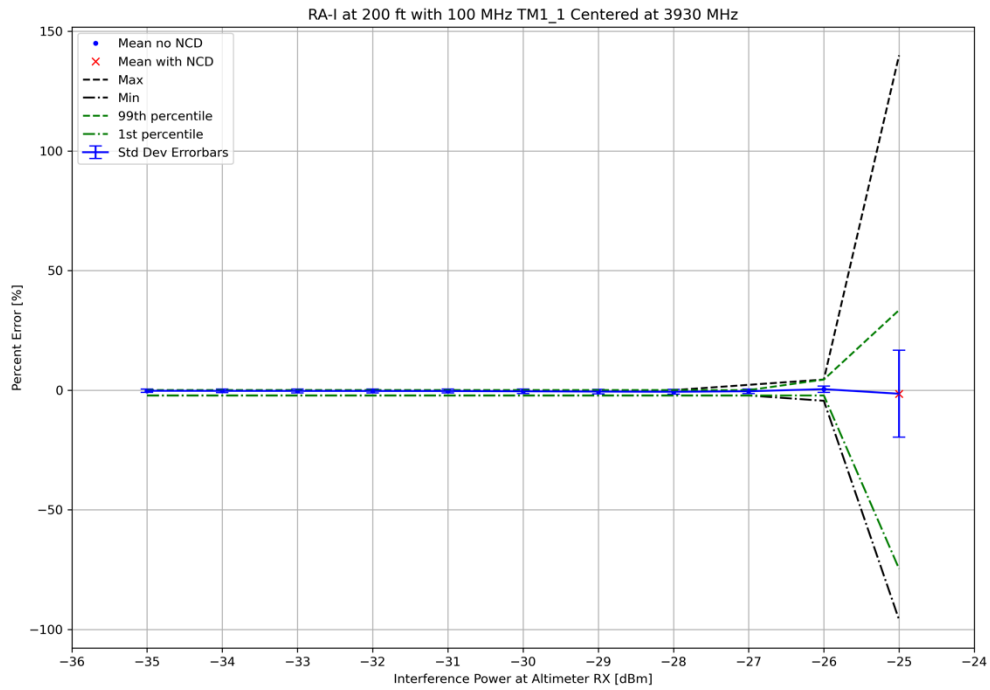


Figure 3-220: UC3 RA-I 200' AGL Statistics with TM1.1 at 3930 MHz – Zoomed Out

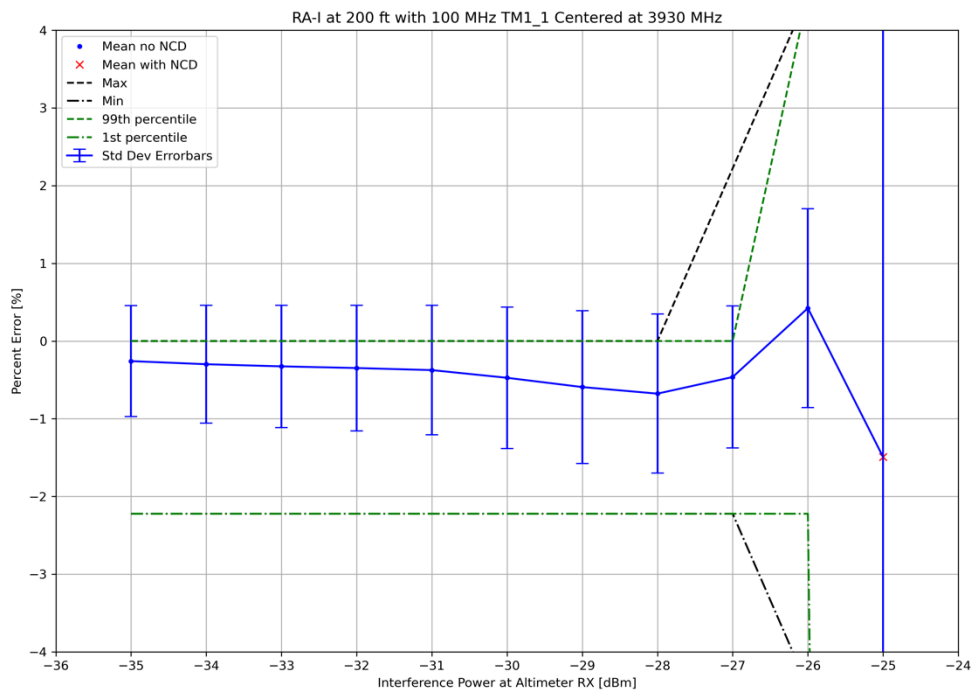


Figure 3-221: UC3 RA-I 200' AGL Statistics with TM1.1 at 3930 MHz – Zoomed In

3.4.4 Altimeter S

Table 3-44: UC3 RA-S 200' AGL OOB Fundamental Emissions Break Point Summary

Center Frequency	Plot	Comments
3750 MHz	Time History Figure 3-222	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-223	No break observed.
3850 MHz	Time History Figure 3-224	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-225	No break observed.
3930 MHz	Time History Figure 3-226	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-227	No break observed.

Center Frequency = 3750 MHz

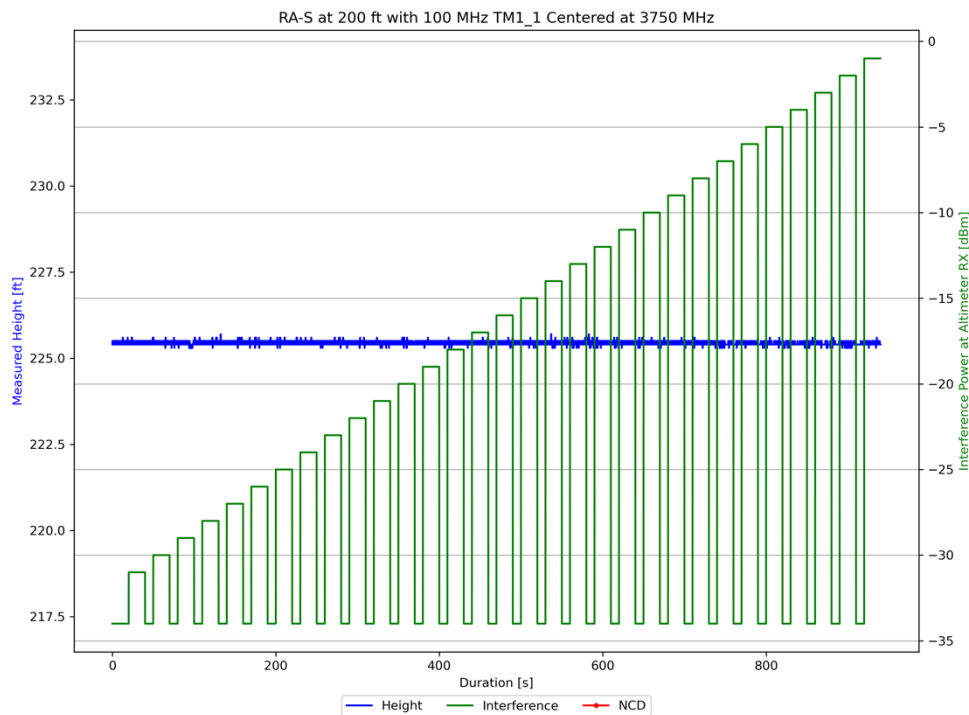


Figure 3-222: UC3 RA-S 200' AGL Time History with TM1.1 at 3750 MHz

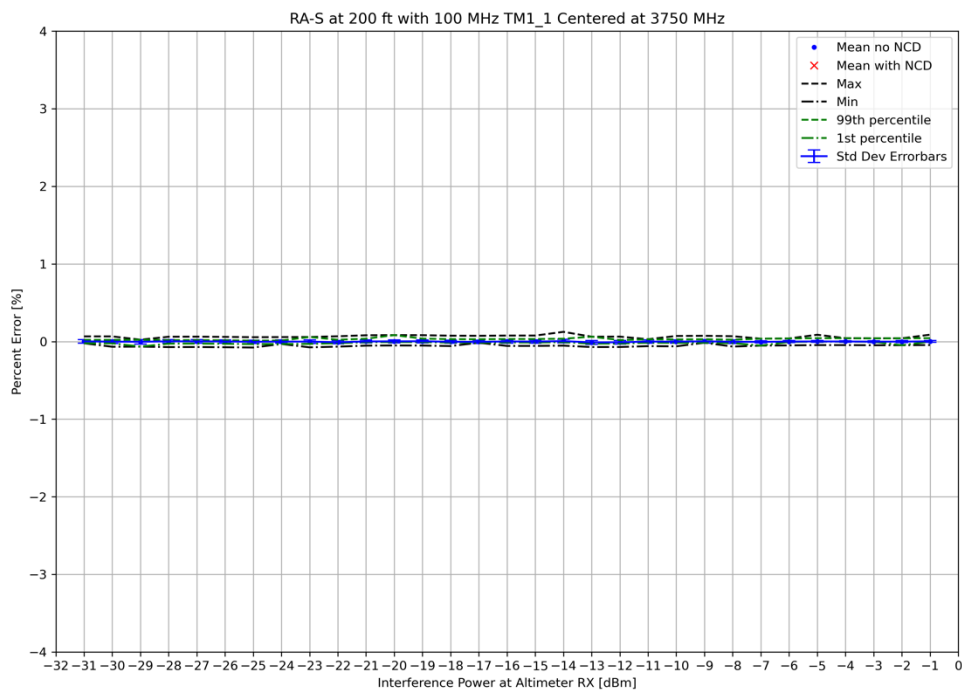


Figure 3-223: UC3 RA-S 200' AGL Statistics with TM1.1 at 3750 MHz

Center Frequency = 3850 MHz

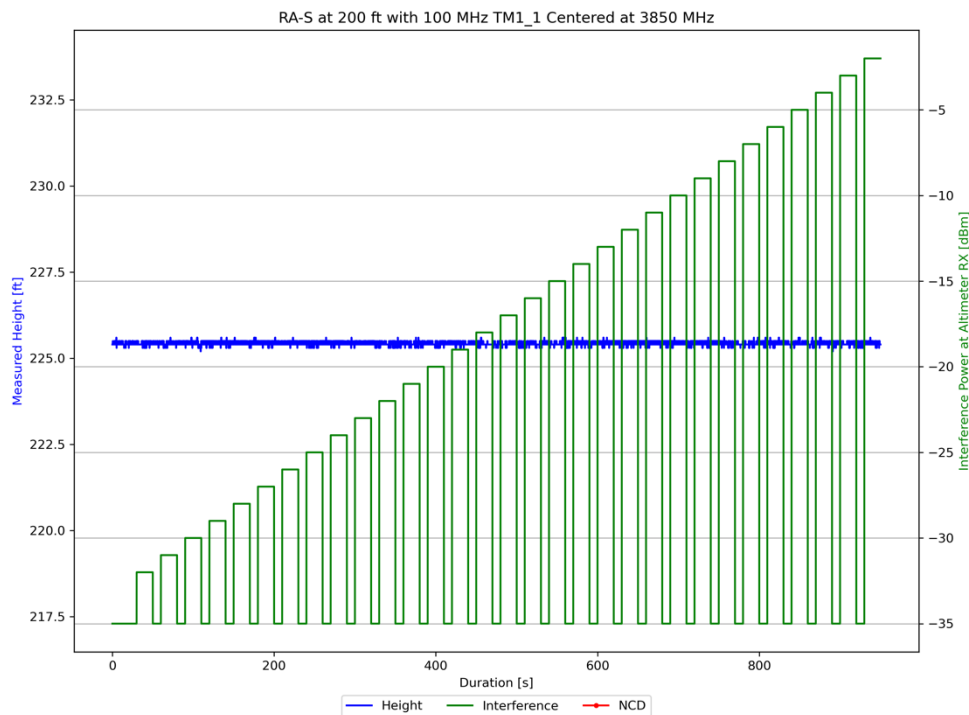


Figure 3-224: UC3 RA-S 200' AGL Time History with TM1.1 at 3850 MHz

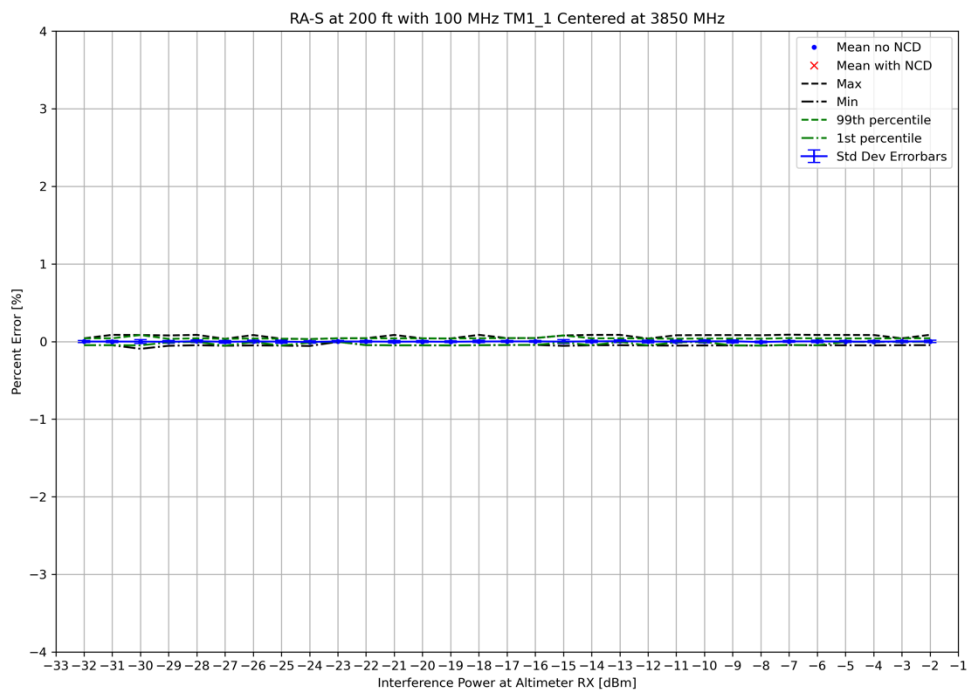


Figure 3-225: UC3 RA-S 200' AGL Statistics with TM1.1 at 3850 MHz

Center Frequency = 3930 MHz

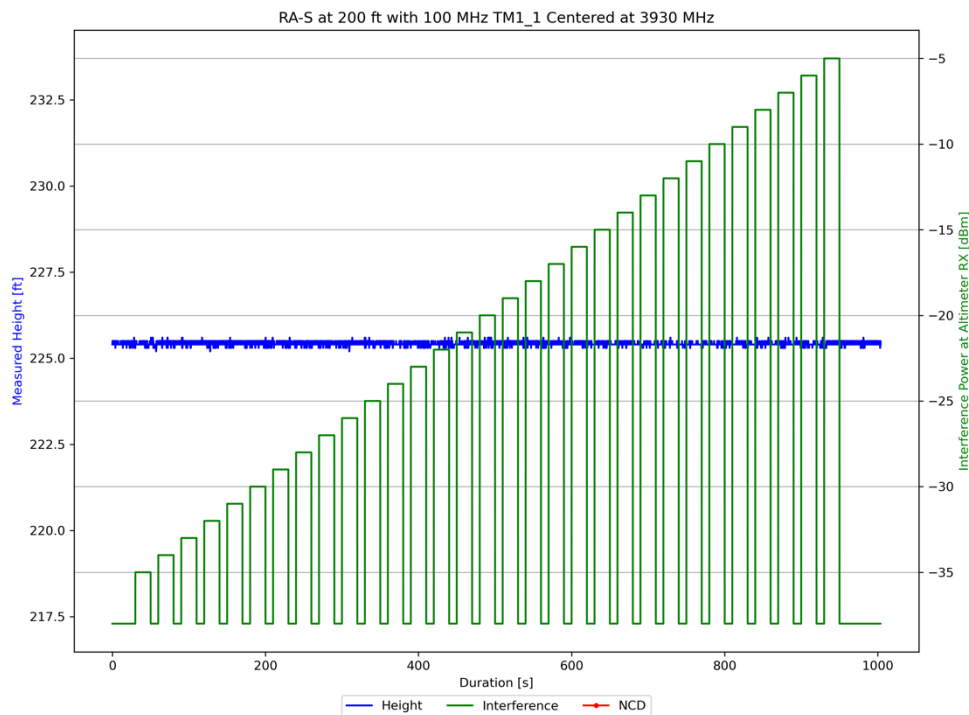


Figure 3-226: UC3 RA-S 200' AGL Time History with TM1.1 at 3930 MHz

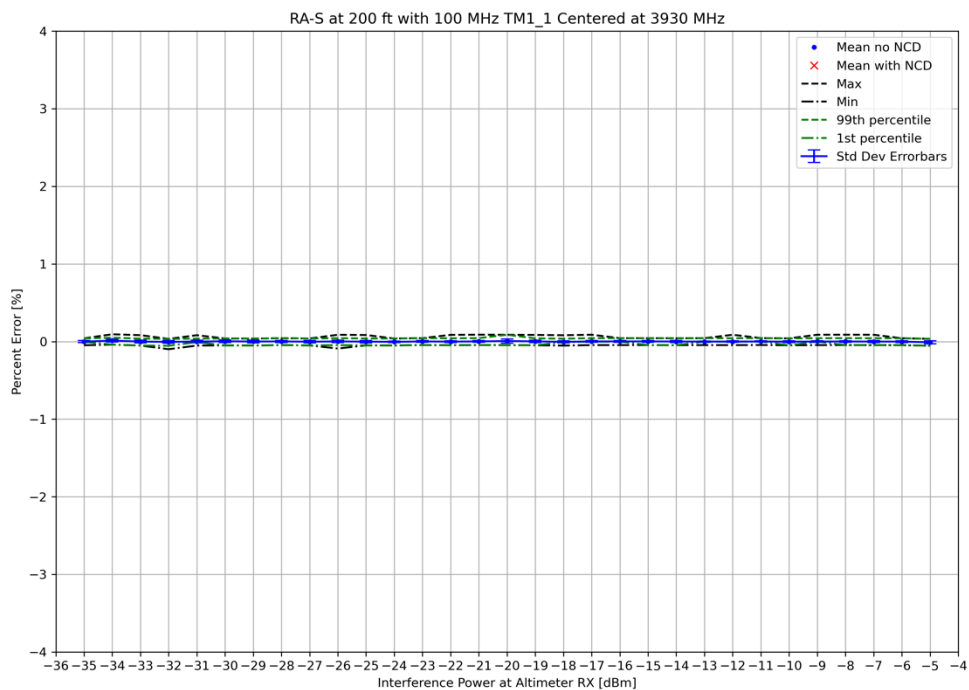


Figure 3-227: UC3 RA-S 200' AGL Statistics with TM1.1 at 3930 MHz

3.4.5 Altimeter V

Table 3-45: UC3 RA-V 200' AGL OOB Fundamental Emissions Break Point Summary

Center Frequency	Plot	Comments
3750 MHz	Time History Figure 3-228	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-229 Figure 3-230	<p>Mean error first exceeds the $\pm 0.5\%$ criterion threshold near -46 dBm.</p> <p>99th percentile measured height is greater than the +2% criterion threshold near -42 dBm.</p> <p>An NCD occurs near -41 dBm.</p> <p>While the mean error exceeds the threshold at a lower power, subject matter experts considered the statistics plot (Figure 3-229) and applied engineering judgement to conclude that the break point is at -42 dBm. Thus, the break point is set by the 99th percentile criterion at -42 dBm.</p>
3850 MHz	Time History Figure 3-231	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-232 Figure 3-233	<p>Mean error first exceeds the $\pm 0.5\%$ criterion threshold near -38 dBm.</p> <p>99th percentile measured height is greater than the +2% criterion threshold near -34 dBm.</p> <p>An NCD occurs near -34 dBm.</p>
3930 MHz	Time History Figure 3-234	Shows magnitude of change in measured height over time for increasing interference power levels.
	Statistics Figure 3-235 Figure 3-236	<p>The plot shows that the RA was still recovering from the previous power sweep (CF = 3850 MHz) when this power sweep (CF = 3930 MHz) was initiated, as indicated by the spike in the measured height near t=0. These data can be excluded from the statistical analysis.</p> <p>Mean error first exceeds the $\pm 0.5\%$ criterion threshold at -40 dBm.</p> <p>99th percentile measured height is greater than the +2% criterion threshold at -36 dBm.</p> <p>The first NCD occurs at -36 dBm.</p> <p>While the mean error exceeds the threshold at a lower power, subject matter experts considered the statistics plot (Figure 3-235) and applied engineering judgement to conclude that the break point is at -37 dBm.</p>

Center Frequency = 3750 MHz

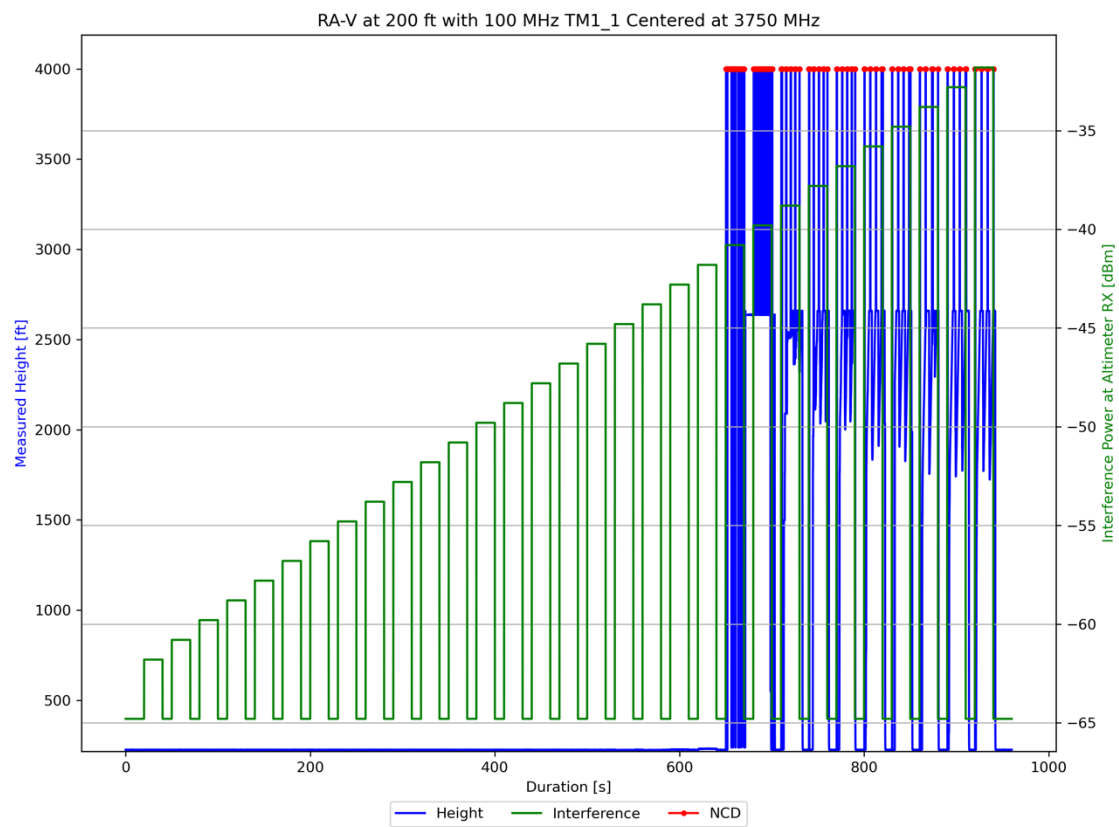


Figure 3-228: UC3 RA-V 200' AGL Time History with TM1.1 at 3750 MHz

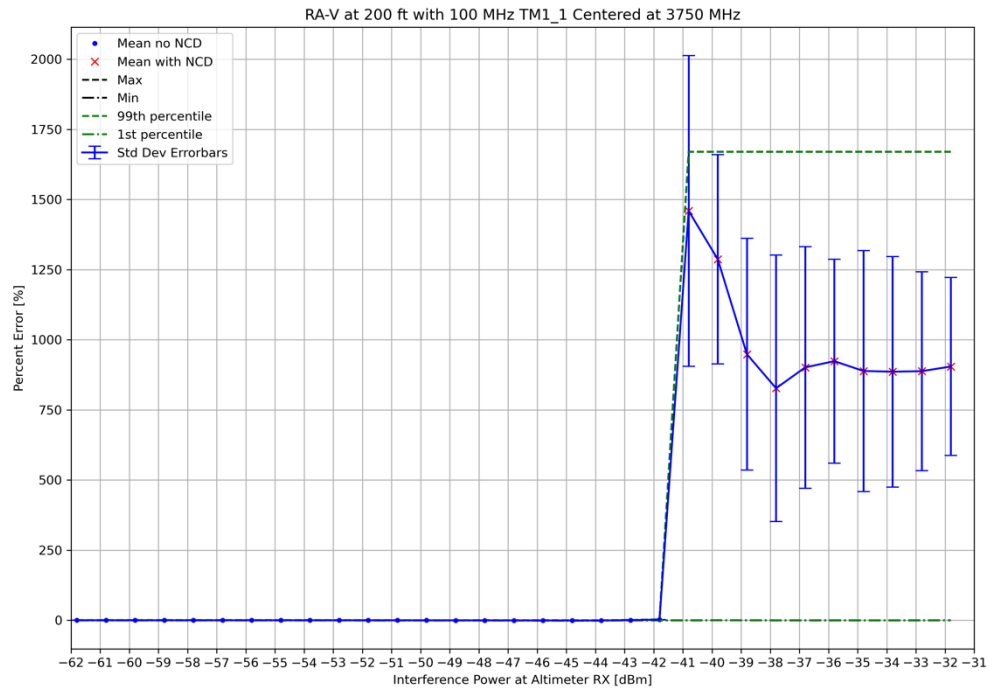


Figure 3-229: UC3 RA-V 200' AGL Statistics with TM1.1 at 3750 MHz – Zoomed Out

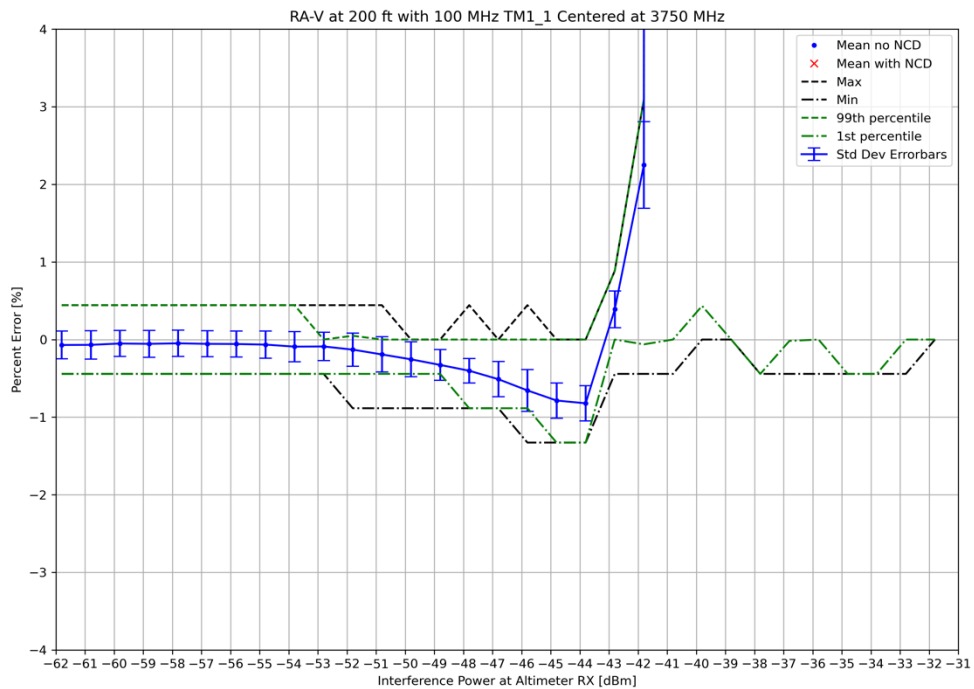


Figure 3-230: UC3 RA-V 200' AGL Statistics with TM1.1 at 3750 MHz – Zoomed In

Center Frequency = 3850 MHz

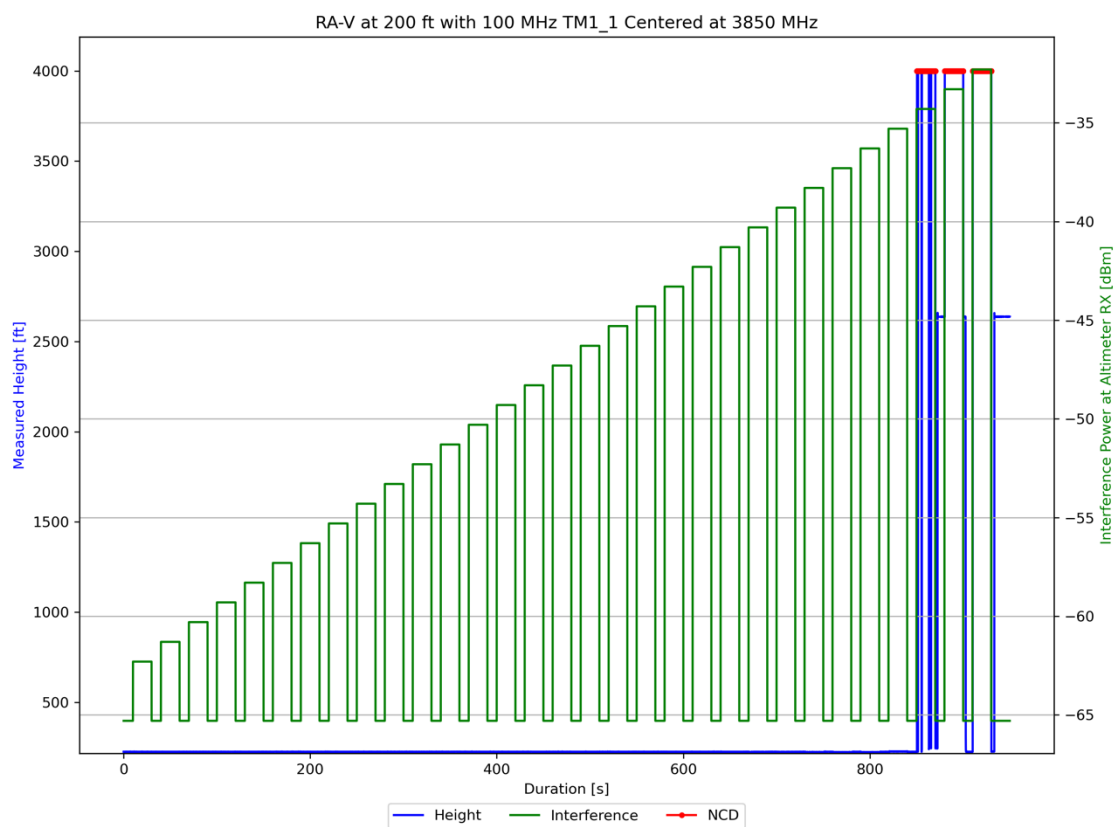


Figure 3-231: UC3 RA-V 200' AGL Time History with TM1.1 at 3850 MHz

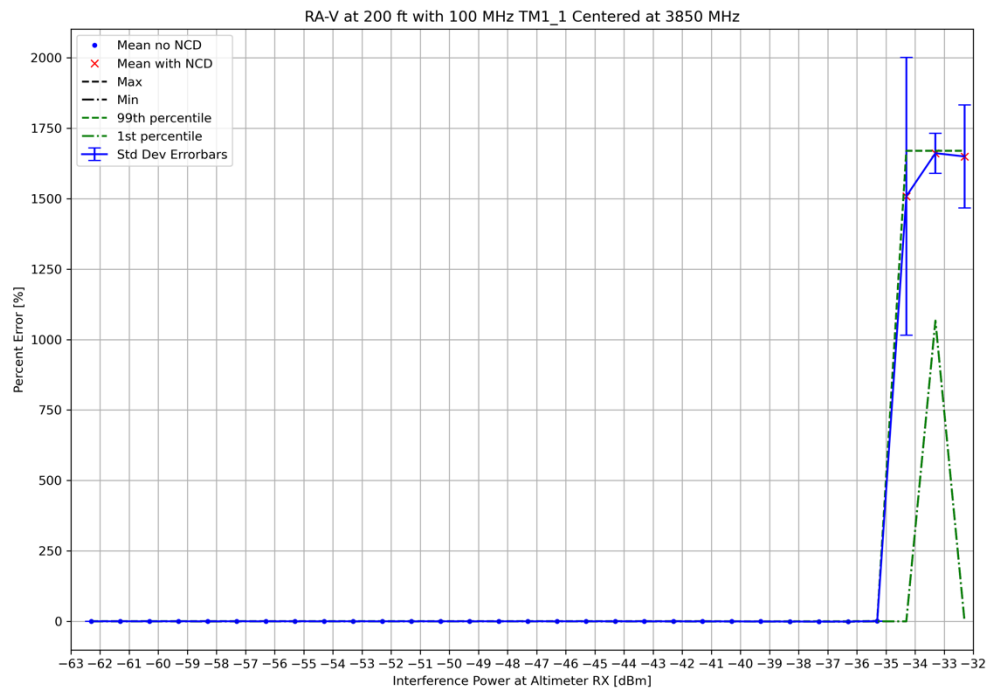


Figure 3-232: UC3 RA-V 200' AGL Statistics with TM1.1 at 3850 MHz – Zoomed Out

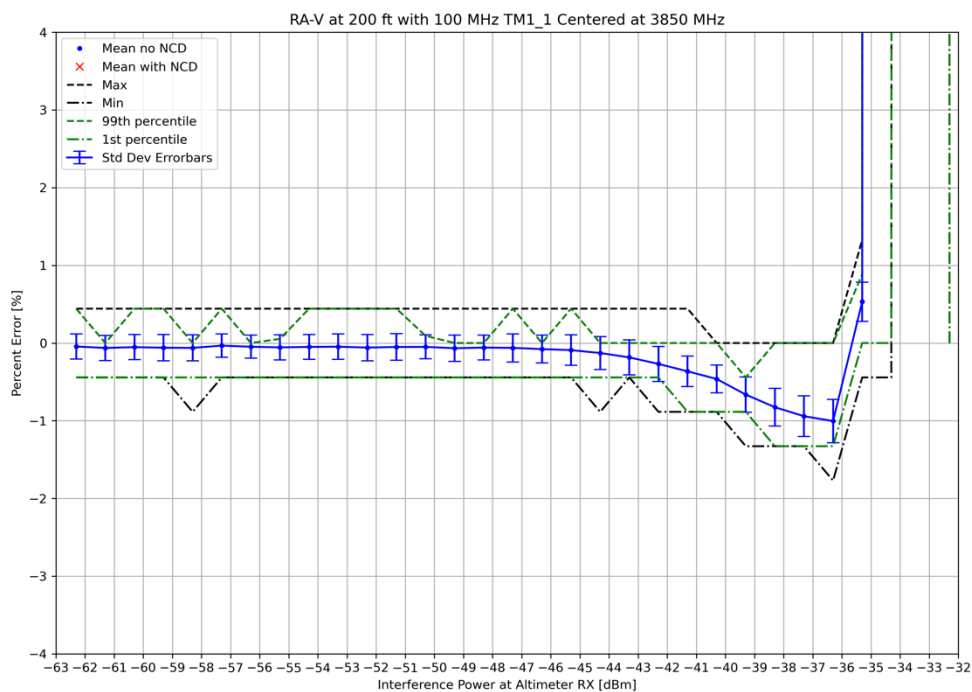


Figure 3-233: UC3 RA-V 200' AGL Statistics with TM1.1 at 3850 MHz – Zoomed In

Center Frequency = 3930 MHz

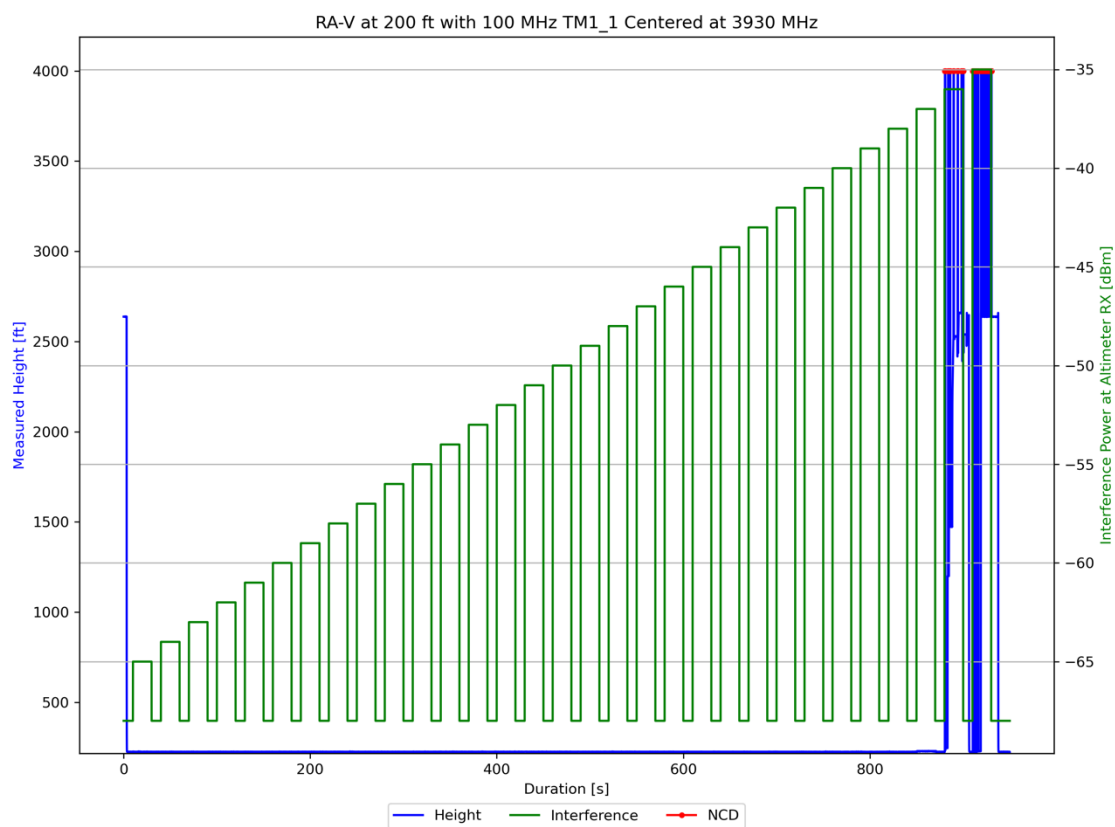


Figure 3-234: UC3 RA-V 200' AGL Time History with TM1.1 at 3930 MHz

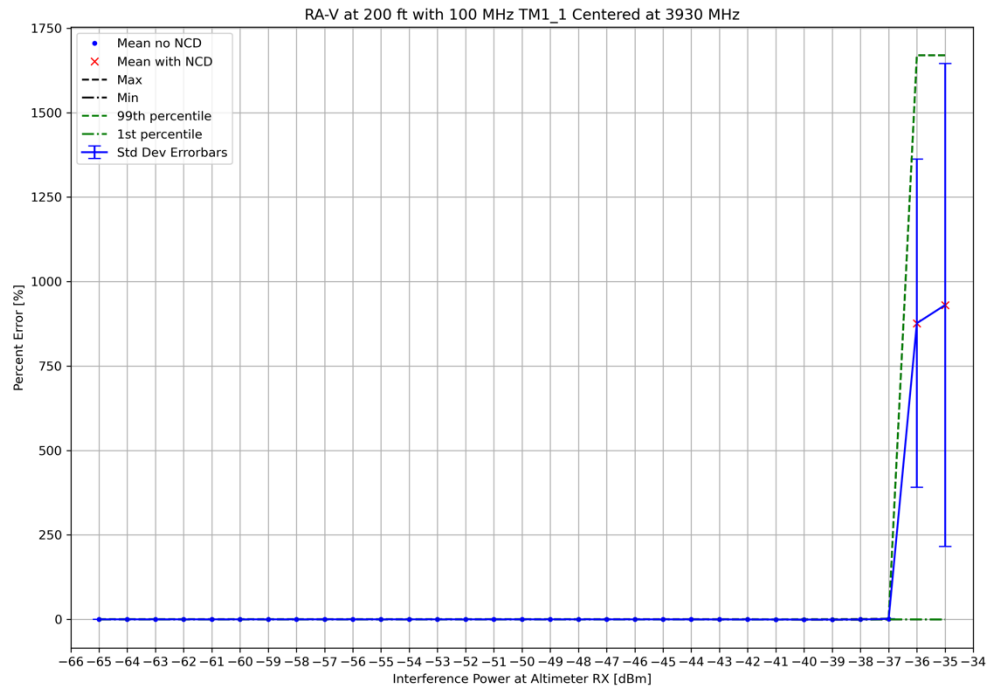


Figure 3-235: UC3 RA-V 200' AGL Statistics with TM1.1 at 3930 MHz – Zoomed Out

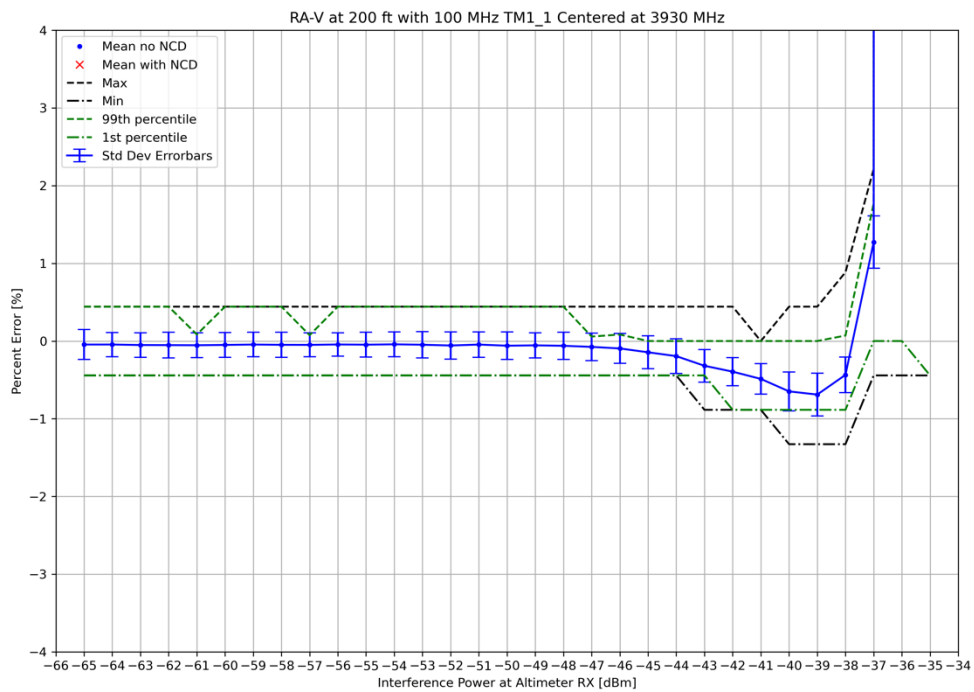


Figure 3-236: UC3 RA-V 200' AGL Statistics with TM1.1 at 3930 MHz – Zoomed In